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Organisms and Environment

CONTENT

SYLLABUS

Organisms and Environment

Abiotic Factors, How do Organisms Respond to Abiotic Factors, Adaptation, Populations, Growt Models, Population Interactions

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Ecology is the study of interaction among organisms and between the organisms and their abiotic or physical environment.

The ecology is concerned with the following 4-levels of the biological organization.

(1) Organism level (2) Population level (3) Community level (4) Biome level

This chapter is dedicated to the first 2-levels of the biological organization, i.e., Organisms and Populations.

At 'organism level' we will study adaptations of the organisms to their environment. The adaptation may be for their survival or for the process of reproduction. Such an aspect of ecology is called *'Physiological ecology'*.

The seasonal variation of temperature and precipitation (including rain, snow and sleet etc.) are responsible for the formation of major biomes like, Rain forest, deciduous forest, Desert, Tundra and Sea coast etc. The local variations (Physical or chemical) in each biome further differentiate various habitats like, polar regions, high mountain tops, rain soaked forests (Meghalaya), Rajasthan deserts, ocean trenches and hot springs etc.

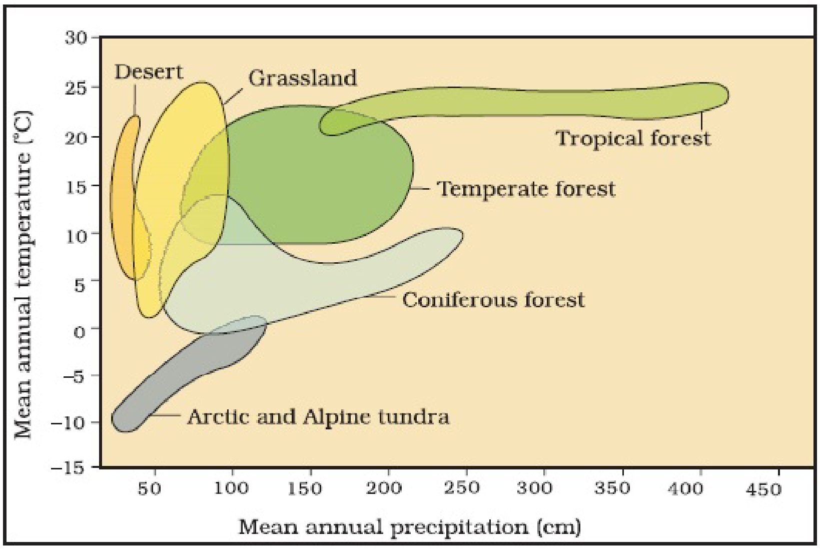


Fig. : Major Biomes of India with respect to annual temp. and precipitation

- Each habitat comprises both of abiotic components. The most important abiotic components (physical or chemical) that characterize various habitats include - *temperature, light, water and soil.* The biotic component that interact with the organisms include mainly *pathogen, parasites, predators* and *competitors*. Over a period of time the organisms evolve through natural selection to optimize their survival and reproduction in a given habitat.

ABIOTIC FACTORS

1. Temperature

- It is the most important factor and plays a significant role in determining the habitat. A few organisms, that can tolerate a wide range of temperature, are called Eurythermal, and the majority of the organisms that tolerate a narrow range of temperature, are known as Stenothermal.
- The temperature ranges from 00 C in polar region to > 500 C in tropical regions. Even in the same habitat the temperature may vary from one season to another. There are some unique habitats, such as hot springs and hydrothermal vents, where the average temperature exceed 1000 C.
- You are aware about the habitats of mango tree, polar bear, snow leopard and tuna fish etc. The mango trees of tropical and sub tropical region can not grow in temperate countries like Germany and Canada. The polar bear and Snow leopard can not be found in the forests of Tamil Nadu, Kerela etc. and similarly the tuna fish is not found in the oceans of temperate region.
- The problem of global warming in recent years is affecting the distribution range of various species.

2. Light

- Most of the plants **(Autotrophs)** require sun light for the synthesis of food (photosynthesis). Some plant like shrubs and herbs photosynthesise in low light conditions. The marine plants (algae), inhabiting different depth of ocean, need different colour components of visible spectrum. The red algae (with red pigment, **Phycoerythrin**), as compared to brown or green algae, is found in greater depth of sea and absorbs blue light for photosynthesis.
- The sun light can not penetrate deep into the ocean. At the depth of > 500 m the inhabitants live in dark and can not photosynthesize for energy production. The source of energy in such deep sea organisms (like bacteria) is *Chemosynthesis.* The animals of deep sea areas are either blind or show *bioluminescence*.
- The animals also require light for their diurnal and seasonal activities. The foraging migration and reproduction depend on specific photoperiods (duration or exposure) and intensity of light. The sun light is also the source of heat and varies from one biome to the other.

3. Water

The water is another important abiotic factor that influences the life of the organisms. As you know that life on earth has originated in water and without water life can not be substained. The availability of water, in the form of precipitation, is different in different biomes. In desert, the plants and animals have special adaptations for the scarcity of water. In aquatic organisms the pH and chemical composition of water are important for their survival. The salinity (the salt concentration in ppm, i.e., *parts per thousand)* is < 5% in inland water, 32–35% in sea water for a long due to osmotic problems. The same happens when a marine animal is transferred to a fresh water body.

The organism that can tolerate a wide range of salinity are called **Euryhaline**, while other, who can tolerate only a narrow range of salinity are called **Stenohaline** *(Please do not confuse these terms with Eurythermic and Stenothermic respectively).*

4. Soil

The study of soil, an **Edaphicv factor,** is called **Pedology**. The soil is weathered superficial layer of earth's crust which is intermixed which the living organisms. The nature or properties of the soil varies form place to place, depending upon climate, weathering and the process of soil development. The plants development. The plants depends upon soil for nutrients, water supply and anchorage. The holding capacity, pH, percolation properties, topography and mineral composition determine the types of vegetation in the area. A good fertile soil consist of mineral matter (~40%), water / soil- solution (~25%), soil air (~25%) and organic matter (~10%). The 'loam' is best for the plant growth. The soil also affect seeds - germination, size of plants, depth of the roots system, susceptibility to frost and parasites, and the flowering in the plants. The type of vegetation also determine the type of animals which it supports. In case of aquatic environment, it is the type of sediments that determines the category of the thriving organism.

HOW DO ORGANISMS RESPOND TO ABIOTIC FACTORS

The fitness of a species in a particular environment depends upon the efficiency all physiological and biochemical processes within the body.

Some of the animals maintain their body temperature or osmotic concentration of body fluid to the optimum level and maintain a constant internal environment (a process called **Homeostasis**). Their performance is the maximum regardless of the weather conditions outside the body. To maximum the working efficiency, human uses artificial means, like air conditioner, in summer, or heaters / blowers, in winter. The animals, however, have natural means, mainly physiological, to manage such stressful conditions.

There are 3 - categories of animals that have specific ways to respond to external environment (or abiotic factors).

1. Confirmers 2. regulators 3. Partial regulators

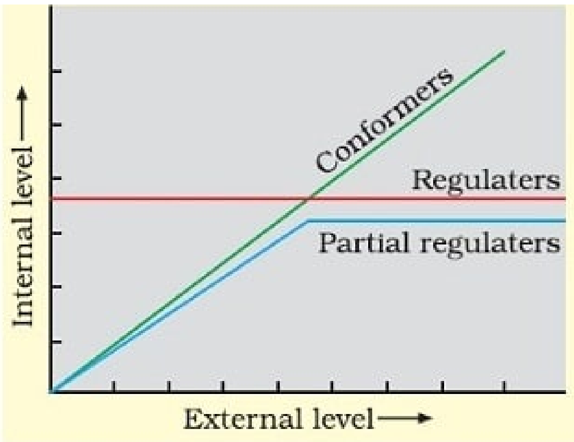


Fig. : Response of organisms to abiotic factors

1. Confirmers

Majority of the animals (up to 99%) and nearly all plants, cannot maintain a constant internal environment. Their body temperature and osmotic concentration changes according to the surrounding conditions. Such animal and plants are called *Conformers*. Both, the thermal regulation and osmo-regulation are energetically expensive processes, that's why such a vast number of animals have not adopted such ways to maintain a constant internal environment. It is still more difficult for the smaller animals, who have larger body surface area in comparison to their volume. Such organisms tend to lose their body heat very fast, when it is cold outside, or expend much energy to cool the body when it is hot outside. This is the main reason why very small animals are rarely found in polar region.

2. Regulators

Some animals maintain their homeostasis by physiological or behavioural means. All birds and mammals (Homeothermic or Warm blooded) and a few lower vertebrates and invertebrates can maintain constant body temperature and constant osmotic concentration regardless of the surrounding conditions. Such organisms are called *Regulators*.

Human constantly maintain their body temperature at 37«C. When it is hot outside (in summer) we start sweating (primarily for cooling the body) and when the surrounding temperature is lower than the body temperature (in winter), we start shivering. The muscle contraction produces heat to raise the body temperature.

The plants do not have any such mechanisms to maintain internal temperature.

3. Partial regulators

If the stressful condition are localized, the animals can *'escape in place'* and migrate to nearby region, having better environmental conditions. If the unfavourable conditions are for a shorter duration then the animals can *'escape in time'* and avoid those conditions suspending their activities. Based upon the situation, the partial regulators may proceed for migration or for suspension of body activities.

(i) Migration

The animal can move away temporally from a stressful environment to a more hospitable area and return when the environmental conditional are favourable. Every winter thousands of birds migrate from Siberia(extremely cold) to Keoladeo National park in Bharatpur (Rajasthan)

(ii) Suspension of body activities

During unfavourable conditions the lower plants, fungi and bacteria, produce thick-walled spores which germinate when the environmental condition are favourable. The seeds and the other vegetative reproductive-structures of higher plants similarly undergo ***'dormancy'*** and reduce their metabolic activities when the conditions are unfavourable, and form new plant when the moisture and the temperature conditions are suitable.

The animals that cannot migrate, avoid the stressful condition for the time period (*escape in time*) and undergo either Hibernation (in winter), e.g., Bear ; or ***Aestivation*** (in summer), e.g. snail and few fishes. Frog undergoes hibernation in winter and aestivation in summer.

When the condition are unfavourable, many species of zooplanktons, in lakes and pond, are known to enter ***'diapause'*** , i.e., a stage of suspended development. Such diapause also occur in eggs, larvae or pupae of insects in adverse condition and breaking occurs when favourable conditions returns. The diapauses, i.e. arrested development, in insects may depend upon the photoperiod, temperature and the hormonal conditions.

ADAPTATIONS

- They are the morphological, physiological or behavioural attributes that enable the organisms to survive and reproduce in their habitat.
- The behaviour or temporary migration to avoid unfavourable condition, or the suspension of growth and development and reduction of metabolic activity are also adaptations.
- In the following paragraph the morphological and physiological adaptations in plants and animals have been described.
- Many desert plants **(Xerophytes)**b have following adaptations to reduce water loss through transpiration.
    - They have either no leaves or the leaves are small, scaly or are reduced to spines (e.g., Opunita). If the leaves are present, they are covered with thick cuticle. In some desert plants there is rolling or folding of leaves.
    - The stomata are arranged in deep pits (sunken stomata) to minimize water loss through transpiration.
    - They have special photosynthetic pathway **(CAM)** so that stomata may remain closed during the day.
    - In some desert plants the leaves or stem are succulent to absorb or store water during brief rainy season.
    - Some plants have high osmotic pressure to endure desiccation.
- In still other plants, the root system is very extensively developed.
- The desert animals **(Xerocoles)**, besides aestivation (summer-sleep) or diapause, also have morphological and physiological adaptation.

  The **kangaroo rats** of North American deserts have following adaptations -
    - They meet their water requirement through internal fat oxidation where the water is a byproduct.
    - They have no sweat glands.
    - They are burrowing and seal the burrow during day to keep inside moist.
    - To avoid heat they are active (for feeding) during night (nocturnal).
    - The **camel**, called the ship of desert, similarly has following adaptations for desert life.
    - They have low surface area to body size.
    - They excrete highly concentrated urine and can withstand dehydration up to 25% of their body weight.
    - They have thick foot pad, thick skin and hard lips.
    - They have Hump for the storage of fat, which on oxidation produces water as byproduct.
- The **desert lizards** maintain their body temperature fairly constant by following *behavioral adaptations -*
    - When their body temperature drops below their comfort zone they bask in the sun and absorb heat.
    - When the surrounding temperature starts increasing they move into shady area.
    - They even burrow into the soil to escape above - ground heat and may feed at night (nocturnal) when ambient temperature drops.

The following are the adaptations in animals of colder region to minimize the body - heat loss -

- The polar animals have shorter extremities like ear, nose and appendages to minimize heat loss **(Allen's rule)** . The aquatic mammals (e.g., Whale and seal) have thick layer of fat (called **Blubber**) beneath the skin. The blubber acts as insulator and reduces loss of body heat.
- Many fishes thrive below ice at sub-zero temperature of Antarctic Ocean. The ice, here, acts as insulator and prevents the under lying water from freezing.

- Some organisms have physiological adaptations by which they can respond quickly to stressful conditions. When we go to a higher altitude (> 3500 m), say Rohtang Pass, near Manali, or Mansarovar in Tibet, we develop **'altitude sickness'** with the following symptoms -

(i) Nausea and vomiting (ii) Heart palpitation (iii) High breathing rate (iv) Fatigue

This happens because at higher altitude the partial pressure of oxygen (atmospheric pressure) drops and sufficient oxygen is not available. But gradually you are acclimatized or physiologically adapted and the symptoms of altitude sickness disappear. This happens by –

1. Increase in the number of RBC - production
2. Decrease in binding capacity of haemoglobin
3. Increase in the breathing rate

Certain marine invertebrates and fishes are well adapted to survive at a great depth of the ocean where the pressure can be more than 100 times of the normal atmospheric pressure. The organisms living in such extreme condition of low temperature and crushing pressure have following biochemical adaptations.

- They body of some animals, like salpa, jelly fishes are completely filled with water where increase of pressure does not have much effect.
- Many fishes have swim bladder that contain compressed gases.

(Please remember that hydrostatic pressure increases by One.Atm, for every 10 m of depth. This means at 10 m and 100 m the pressure will be 2-atm and 11 - atm respectively)

The biological adaptations include differences in the composition of the cell membrane protein and other biomolecules. It is the high pressure of water column that distorts such complex biomolecules.

POPULATIONS

The population is a group of individuals of a particular species, which potentially interbreed and live in a well defined geographical area, and also share or compete for similar resources.

For ecological point of view a group of asexual individuals is also known as population.

Examples of population are

1. Tigers in a national park
2. Rats in an abandoned building
3. Lotus plants in a pond
4. Teak-wood trees in a forest
5. Bacteria in a petri-dish

The natural selection also operates at population level.

The population has certain attributes or peculiar features which are not represented by the individuals. The important attributes are *Life expectancy, sex ratio, birth rate, death rate, age distribution* etc.

Birth or Natality rate - It is the number of births per thousand of a population per year. It can also be represented in percentage, or per capita, i.e., per individual.

If there were 50 lotus plants in a pond last year. This year the population has increased to 58 due to reproduction, then birth rate per capita can be calculated as

58 – 50 = 8

8 / 50 = 0.16 offspring per lotus per year

Or per capita birth rate per year = 0.16

Death of Mortality rate – It is the number of deaths occurring in a population of one thousand per year.

This can also be represented in percentage or per capita.

If in a population of 50 house flies, 5 died in a week, then the per capita death rate per week can be calculated as 5/50 = 0.1

Life Expectancy – It is the length of time for which an individual of a given species can expect to live. *It is the characteristic of a population,* but not of a species. It is defined as the age at which half the population still survives (M_{50}). The life expectancy differs with sex and time period. In US females the life expectancy (M_{50}) was 58, 76 and 81 in the years 1900, 1960 and 1980 respectively.

- **(Life Span –** It is the maximum number of years a member of a species has been known to survive. The life span of human is estimated to be 121 years. The (maximum) life span is the characteristics of a species. In Drosophila, Domestic dog and Tortoise the life spans are 3 months, 20 years and more than 150 years respectively.)
- **Population growth –** The gross value of population growth is calculated as the difference of birth rate and death rate.
- **Dispersal –** The movement of the individuals in or out of the population affects the size of population. The movement of individuals into a population is called **Immigration**, and movement, out of the population is called **Emigration.**
- A set of local populations connected by dispersing individuals is called a **Metapopulation.**
- The *accurate population growth* involves migrant individuals also, which means the –
- **Population growth = (Birth rate + Immigrants) – (Death rate + Emigrants)**
- **Zero population Growth –** When birth rate equals death rate, and the growth of the population is Zero, i.e. the size of the population remains constant, it is called Zero Population Growth or **Demographic Transition.** Considering migration, at zero population growth :
- **Birth rate + immigrants = Death rate + emigrants**
- Bio-index number – It is the ratio of birth rate to the death rate. In case of Zero population growth the bio-index number is one

$$\textbf{Bio - index number} = \frac{\text{Birth rate}}{\text{Death rate}}$$

- **Population size :** The population size may range from few individuals to millions depending upon species, geographical area, impact of predators, outcome of competition and effect of pesticides etc. Sometimes the population size is either too big to measure or meaningless, then the size is more technically called as population density.
- The **population density** can be defined as the number of individuals per square unit area (in terrestrial organisms) or per cubic unit area (in aquatic or aerial organisms). Sometimes the population density is not required and only Relative density serves the purpose. For example, the fish caught per trap in a lake can be used as population density.
- If we compare about 200 *Parthenium* plants which one huge Banyan tree, the population density too becomes less useful. In such cases the **Biomass** or percent cover is used for the measure of population size. In some cases the organisms cannot be seen or counted directly, then the population size is measured indirectly from faecal pellets or pug marks etc.

- **Sex ratio –** It is the number of females per thousand of males. According to 2001 census it was 933.
- **Age and Sex structure –** It is the proportion of individuals of different age and sex. It is depicted in pyramidal form plotting percentage of population of each sex in each age-class.
- In developing countries, like India, it is less steep as it has a larger number of younger people. In developed countries it is steeper which represents nearly stable population.

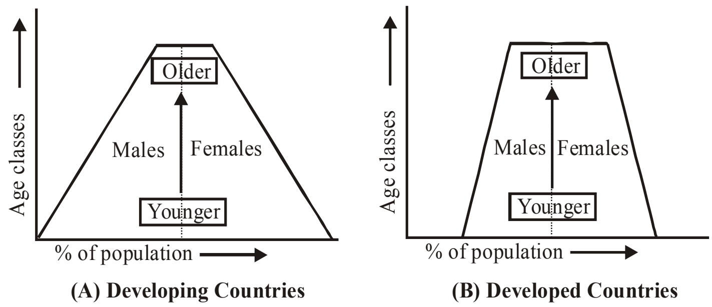


Fig. : Age sex ratio in (A) Developing Countries and (B) Developed Countries

Age distribution Pyramids – For constructing age pyramids, 3-age groups are taken into consideration.

1. Pre-reproductive age (0–14 year)
2. Reproductive age (15–60 years)
3. Post reproductive age (> 60 years)

There are 3-types pyramids, i.e. 1. Triangular, 2. Bell shaped and 3. Urn-shaped

1. **Triangular Pyramid –** It indicates **expanding population** with high growth rate.
2. **Bell shaped pyramid –** It indicates **stable population** with Zero growth rate.
3. **Urn–shaped Pyramid –** it indicates **detecting population** with growth rate in minus.

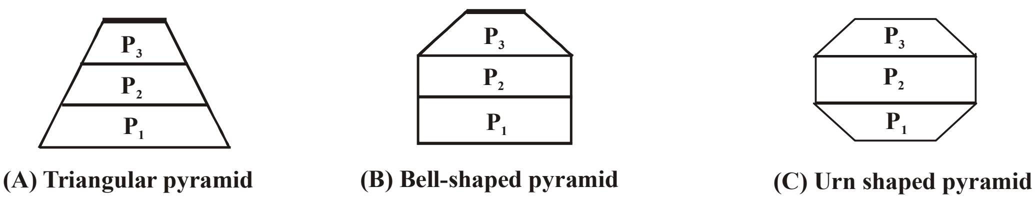
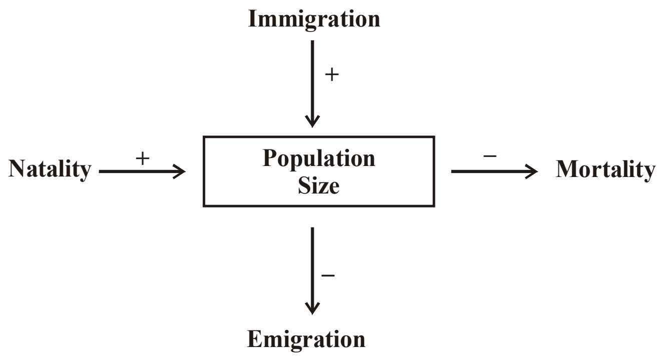


Fig. : P_1 = Pre-reproductive age, P_2 = Reproductive age P_3 = Post reproductive age

Population growth : The population density is not a static parameter and keeps changing in times. The population size depends on the availability of food, weather conditions, predation pressure etc.

The population size or density in a given area or habitat, during a given period depends upon the 4-basic processes

1. Natality (B) 2. Mortality (D) 3. Immigration (I) 4. Emigration (E)



If N is the population density at time t, then density at time (t+1) will be

$$n(t+1) = N(t) + [(B+I) - (D+E)]$$

Until and unless a new habitat is being colonized, the birth and death are the most important factors for influencing the population density.

GROWTH MODELS

The growth of population with time shows specific and predictable patterns. The 2-common patterns are

1. Exponential or geometric growth pattern 2. Logistic growth pattern

1. Exponential growth

When resources like food and space etc. in a habitat are unlimited, each species realizes its full reproductive or biotic potential and grows in an exponential or geometric fashion. For example if a reindeer population (N) is allowed to grow in a predator free environment, the population in time 't' grows beyond carrying capacity and forms 'J' shaped growth pattern/ curve. Such growth also occurs in algal bloom, insects during rainy season and *Paramecium* (doubling every day).

Thus under unlimited resources and absence of check any species can grow exponentially.

Even the slowest breeder, elephant (gestation period - 22 months can grow to enormous number.

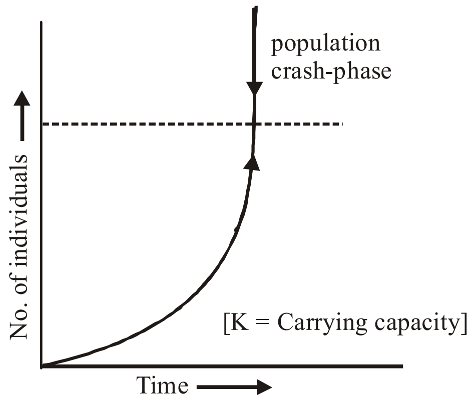


Fig. : Population Growth Curve (J - shaped)

If the population size is 'N' and birth rate and death rate per capita are respectively 'b' and 'd', then the change in population size, i.e., increase or decrease during a unit time period 't', will be

$$\frac{dN}{dt} = (b-d) \times N$$

If (b–d) = r, then $\mathbf{\frac{dN}{dt} = rN}$

Here 'r' is called **'Intrinsic rate of natural increase'** or **Biotic potential (maximum capacity of reproduction),** Which indicates the impact of biotic and abiotic factors in population growth. The value of 'r' for human population in 1981 in India was 0.02.

Problem 1. If the population of rats in an abandoned dwelling in 2001 was 200, and in 2005 it was 240, then find the value of 'r'

$$\frac{dN}{dt} = rN$$

$dN = 240 - 200 = 40$

$dt = 2005 - 2001 = 4$

$\frac{40}{r} = r \times 200 ; \frac{10}{200} = \mathbf{0.05}$ individuals per rat per year.

Problem 2. If the population doubles in 3 years. What is the intrinsic rate of increase of the population ?

$$\frac{dN}{dt} = rN$$

$$\frac{(2N - N)}{3} = rN$$

$$r = \frac{N}{3 \times N} = \frac{1}{3} = 0.33$$

The integral form of exponential growth equation is

$\mathbf{N_t = N_0 e^{rt}}$

N_t = population density after time 't'

N_0 = Population density at time zero, '0'

r = Intrinsic rate of natural increase

e = the base of natural logarithms (2.718..)

2. Logistic growth

In nature to species has unlimited resources at its disposal to permit exponential growth. There starts competition between individuals for limited resources. The population growing in a habitat initially shows 'lag phase', followed by phase of acceleration or deceleration *(log phase)* and finally the stage of **asymptote -** when population density reaches carrying capacity (plateau phase or stationary phase).

If the population density 'N' is plotted against time 't', the result is **'S' shaped** growth pattern / curve **(Sigmoid curve).**

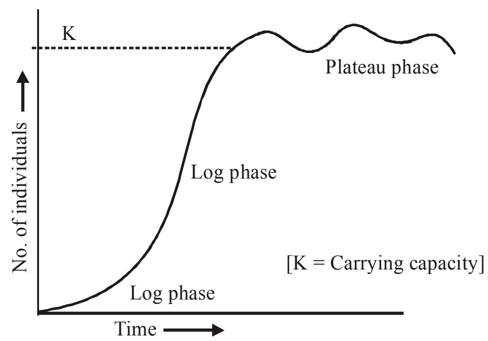


Fig. : Population Growth Curve (Sigmoid, S- shaped)

This type of growth pattern is also called as **'Verhulst-Pearl logistic growth'** and can be represented as following equation

$$\frac{dN}{dt} = rN\left(\frac{K - N}{K}\right)$$

K = Nature's carrying capacity in that habitat

(K–N) / K or 1 –N = environmental resistance

Carrying capacity (K) – It can be defined as the maximum number of individuals which the environment can support or sunstain. Hence, it is the capacity of environment and not of individuals.

The carrying capacity of the environment depends upon 3-components, i.e.

(i) Productive system – It includes cropland, orchard etc. to provide food and fibers.

(ii) Protective system – It includes forest, ocean etc. which regulate temperature and humidity.

(iii) Waste assimilative system – It includes the generation of waste material in water, air and soil.

Environment resistance – The factors like predators, diseases, calamities, shortage of food etc.. Which impose a check on population, form environmental resistance.

Since resources for growth, for most of animal populations, become sooner or later limited the logistic growth model is considered to be the more realistic one.

Variations in life history of organisms

The population evolve to maximize their reproductive fitness with high 'r' value, in the given habitat. This, organisms do by developing the most efficient reproductive strategy under the given selection pressure. For example, the organisms like *Bamboo* and pacific *salmon fish*, breed only once in their life time, while others, like birds and mammals breed many times in their life time. Some organisms (Oysters) produce a large number of large sized offsprings. Thus the organisms maximize their reproductive fitness in the desirable way. This also shows that life history traits have perhaps evolved in relation to constraints imposed by the biotic and abiotic components in their habitat.

POPULATION INTERACTIONS

In nature no species can survive in isolation. Even the plant species, which can synthesize their own food, cannot survive alone. They need soil microbes to break down the organic matter in the soil and return the inorganic nutrients for absorption. Besides, plants also need animals (insects) for pollination. Thus in nature, plants, animals and microbes do not and cannot live in isolation but interact in various ways to form biological community. The interspecific associations arise from the interaction of populations of different species. Such associations can be beneficial, harmful (detrimental) or neutral (neither beneficial nor harmful).

Following are different interspecific associations / interactions. The '+' indicates beneficial interaction, '–' detrimental and '0' neutral interaction.

Population Interaction

S.N.	Name of interaction	Species A	Species B
1	Parasitism	+	-
2	Commensalism	+	0
3	Mutualism	+	+
4	Predation	+	-
5	Competition	-	-
6	Amensalism	-	0

Parasitism

In this interaction one species (Parasite) is benefitted and the other (Host) is harmed (+, -). The parasitism ensure free **lodging** and free **meals**. Many parasites are host specific while others can parasitize on various species of host.

The hosts evolve special mechanisms to reject or resist the parasite. The parasite on the other hand evolves the mechanism to counteract and neutralize their effects. The parasites have following types of special adaptations for their survival

1. Loss of unnecessary sense organs
2. Presence of suckers or adhesive organs to attach the host body
3. Loss of digestive system
4. High reproductive capacity
5. Complex life cycle with one or two hosts.

Majority of the parasites harm the hosts by reducing their growth, reproduction, survival and population density. They may also make the host physically weak and vulnerable to predation. The parasites can be of 3-types

1. Ectoparasite 2. Endoparasite 3. Brood parasite

The **ectoparasite** live or feed on the external surface of the host. The most familiar examples are lice and bed bug on human, tick on dogs and leech on cattle. The mosquitoes cannot be considered as true ectoparasites, since they take only meal from the host body, and don not make lodging. Amongst plants the common example is **Cuscuta,** which has lost both chlorophyll and leaves during evolution and parasitizes hedge plants. The other parasites are copepods, *Petromyzon* and hagfishes, for which the hosts are marine fishes.

Bed bug

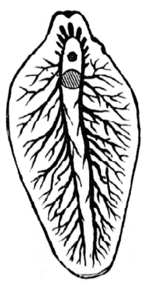
Petromyzon on fish

Tick - Dog

The **endoparasites** live inside the body of the host. Their morphological and anatomical features are greatly simplified, but their life cycles are more complex because of their extreme specialization. Their reproductive potential is very high. They can be **monogenetic** (involving single host) or **digenetic** (involving two hosts). The common monogenetic endoparasites are Ascaris (round warm) and *Entamoeba* in small and large intestine respectively. The familiar digenetic endoparasites are *Taenia* **(tape worm)** *and Fasciolo* (liver fluke) in intestine and liver respectively. The *Plasmodium* is also a digenetic endoparasite in human and female. *Anopheles* mosquito. The filarial worm is similarly a lymph parasite.

The koel or cuckoo is a **brood parasite** and lays the eggs in the nest of the host, crow, who incubates them. The eggs of the parasite bird has evolved resemblances with the host's eggs in colour and shape and size.

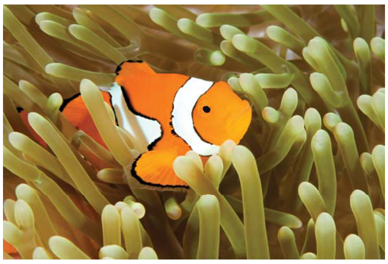
Ascaris Male



Liver fluke

Commensalism

In this interaction one species is benefitted and other is neutral i.e., neither benefited nor harmed (+, 0). The association of *'egret and the cattle'* is the classical example of commensalism. As the cattle move during grazing, they stir up and flush out the insects from the vegetation which otherwise be difficult for the egret to find and catch. Here the cattle gets no benefit from egret. The other examples of commensalisms are 'clown fish hiding in the colony of sea anemone', 'orchid growing as an epiphyte on mango tree' and the 'barnacle growing on the back of whale'. Here, sea anemone, mango tree and whale derive no benefit from the association.



Clown fish with sea anemone

Egret and Buffalo

Mutualism

In this interaction both the species are benefitted (+, +). **Lichens** is such relationship between fungus and photosynthetic algae / cyanobacteria. The **Mycorrhizae** is also a similar association between fungus and the roots of higher plants. The fungi here, helps the plant to absorption of essential nutrients from the soil, while plant provides the food to the fungus. In plant-animal association there has occurred co-evolution of mutualism. In many species of fig trees there is a close one-to-one relationship with the species of wasp, for pollination. The female wasp pollinates the fig inflorescence while searching for suitable site for egg laying (oviposition). She lays the eggs inside the fruit and the seeds of the fruit bare also consumed by the developing larvae of the wasp. Thus, both are mutually benefitted. Some plants have evolved special structures for pollination by insects like bees, butterflies and bumble bees. To ensure guaranteed pollination the Mediterranean orchid **(Ophrys)** employs *sexual deceit*, in which one petal of the flower resembles very closely with the female of the bee in shape, colour and markings. The male bee perceives that petal as female bee and attempts *pseudocopulation* with the flower and during the process, the pollen grains are dusted over the body of male bee. When the same bee pseudocopulates with other flowers, the pollen grains are transferred to them. Thus pollination occurs. This is a fascinating example of co-evolution in orchid and the bee maintaining the close relationship in colour pattern, shape, size and marking.

Fig and Wasp

Ophrys (Orchid)

Predation

Like parasitism, in this interspecific interaction also one species is benefitted and the other is harmed (+, -). The common examples of predator and prey are, Tiger and deer, cat and mouse, and lion and zebra. In a broader ecological sense the sparrow feeding on seed, or the herbivorous animals eating plants, are also predators. The predators have following important roles in the community.

1. They (herbivores) act as a conduit for transferring energy, fixed by plants, to higher trophic levels.
2. They keep prey population under check. Otherwise, the prey may achieve high population density to make the ecosystem.

   (When ever an exotic species is introduced into a new geographical area, the species grow exponentially in the absence of natural predators. The following examples of exotic or alien species will support the above statement.

   Introduction of prickly pear (cactus) into Australia ; Nile perch into lake Victoria (East Africa) and *Eicchornia* into water bodies in India. The other examples of exotic species that spreaded rapidly due to absence of predators are *Parthenium, Lantana* and *Clarias* etc.)

Prickly pear

Lantana

3. Predation also reduces competition amongst preys species and maintains species diversity. (When *Pisaster* (star fish), a predator, was removed from American pacific coast, about 10 species of invertebrates got extincted because of interspecific competition).

If a predator however, overexploits the prey, the prey might becomes extinct, following which the predator may also become extinct due to lack of food. In nature this is a rare event.

The prey species have evolved various defence mechanisms to lessen the impact of predation. They either run away or have poison secretion / stings, warming colouration and distasteful nature in various insects or show camouflage (insects, frogs).

The herbivores are plant predators. Amongst insects about 25% are phythophagous. But unlike animal the plants cannot run away from predators and therefore, have evolved of morphological defense are thorns in *Acacia* and cactus, while chemical defense against herbivores, grazers or browsers, are secretion of nicotine, caffeine and quinine in Tobacco, coffee and *Cinchona* respectively, and cardiac glycosides in *Calotropis*.

Competition

It is defined as an interspecific process in which the fitness of one species (measured in terms of 'r') is significantly lower in the presence of another species. It is (-, -) relationship. Charles Darwin also considered the interspecific competition a potent before in organic evolution. The competition generally occurs when closely related species compete for the same but limiting or depleting resources.

However, competition may also occur between totally unrelated species for the same resource. For example, the Flamingos (birds), visiting S. American lakes, compete with the resident fishes for the common food, zooplanktons.

The competition may ever occur when resources like food and space etc. are abundant, since the feeding efficiency of one species may be reduced due to interfering presence of other species. This competition is called **interference Competition.**

Gause's 'competition exclusion principle' states that two closely related species competing for the same resource cannot co-exist indefinitely and the competitively inferior will be eventually eliminated. This is, however, true only when resources are limited.

The species facing competition may sometimes evolve such mechanisms that promote co-existence rather than exclusion. One such mechanism is **'Resource partitioning',** i.e., avoiding competition by either choosing different timings of feeding or behavioural differences in feeding pattern. In nature the tortoise of Galapagos islands became extinct within decade after goats, competitively superior, were introduced on the island, due to greater browsing efficiency of the goat.

It has also been found in nature that when a competitively superior species is experimentally removed, a species whose distribution is restricted to small geographical area expands its distributional range dramatically and expands into a larger area **(Competitive release)**.

Amensalism

In this association one species is harmed but the other remains neutral (-, 0). For example the fungus, *Penicillium notatum* growing close to bacteria, like Staphlococcus, kills the bacteria due to the secretion of penicillin, whereas the fungus remains unaffected. Similarly the leaves falling from the tree either kill or adversely affect the growth of the seedling population underneath the tree.